Amendments to the Claims

1   1.   (Original) In a Constant Access Time Bounded (CATB) cache, a method

2   comprising:

3   reserving a first number of unallocated lines in the cache for pinned data, the first

4   number being less than the number of lines in the cache; and

5   if data needs to be inserted into the cache as pinned data,

6   selecting a line from the lines reserved for pinned data;

7   storing the data in the line; and

8   inserting the line into a search group of the CATB cache.

1   2.   (Original) The method of claim 1 wherein each line of the cache is

2   stored in non-volatile memory.

1   3.   (Original) The method of claim 2 further comprising:

2   recovering the organization of the cache on power up following a loss of power to

3   the cache by

4   in a first phase of recovery, for each line in the cache

5   determining if the line is allocated;

6   if the line is allocated, inserting the line in a search group of the cache; and

7   if the line is not allocated, inserting the line into a pool of free lines;

8   and

9   in a second phase of recovery, for each search group

10   determining the number of pinned lines in the search group; and

11   adding at least one line from the pool of free lines to each search group

12   that has at least one pinned line.

1   4.   (Original) The method of claim 3 wherein the cache is a disk cache in a

2   processor based system.

1   5.   (Original) The method of claim 1 wherein inserting the line into a

2   search group of the cache further comprises:

3   indicating that the line is allocated;

4   indicating that the line is pinned; and

5   using a tag of the line to map the line to a search group of the cache.

1   6.   (Original) The method of claim 5 wherein:

2   the CATB cache is implemented as a set-associative cache;

3   each search group of the cache is a set of the cache; and

4   inserting the line into a search group of the cache further comprises:

5   using the address of the data as the tag of the line;

6   performing a modulus operation between the tag and the number of sets

7   (N) in the cache (the tag MOD N) to map the tag to a set of the cache;

8   performing a search based on the tag of the line; and

9   inserting the line into a dynamic data structure that represents the set.

1   7.   (Original) The method of claim 6 wherein indicating that the line is

2   pinned further comprises modifying metadata associated with the line to indicate

3   that the line is pinned.

1   8.   (Original) For a whole number N, in an N-way set associative non-

2   volatile disk cache, a method comprising:

3   reserving a predetermined number of lines for pinned data and organizing them

4   into a pool of lines for pinned data;

5   distributing the remaining lines in the cache into N dynamic data structures of

6   approximately the same size to represent the N sets of the cache;

7   if data is to be inserted into the cache as pinned data,

8   inserting the data into a line from the pool for pinned data;

9   marking the line as allocated by modifying metadata associated with the

10   line;

11   determining the set to which the line belongs using a mapping based on

12   the tag associated with the line;

13   removing the line from the pool for pinned data; and

14   adding the line to the set.

1   9.   (Original) The method of claim 8 further comprising:

2   recovering the organization of the cache on power up following a loss of power to

3   the cache by

4   in a first phase of recovery, for each line in the cache

5   determining if the line is allocated;

6   if the line is allocated, inserting the line in a set of the cache using a

7   mapping based on the tag associated with the line; and

8   if the line is not allocated, inserting the line into a pool of unallocated

9   lines; and

10   in a second phase of recovery, for each set in the cache

11   determining the number of pinned lines in the set using the metadata

12   associated with each line in the set; and

13   moving one or more lines from the pool of unallocated lines to each set

14   that has at least one pinned line so that the number of non-pinned lines in

15   each set is approximately the same.

1   10.   (Original) An apparatus comprising:

2   an N-way set associative cache implemented in non-volatile memory

3   a pinned data portion of the non-volatile memory to store a pool of lines for

4   pinned data; and

5   a pinned data insertion module to

6   insert pinned data into a line from the pool of lines for pinned data;

7   mark the line as being allocated by modifying metadata associated with

8   the line;

9   determine a set to which the line belongs using a mapping based on the tag

10   associated with the line;

11   remove the line from the pool for pinned data; and

12   add the line to the set.

1   11.   (Original) The apparatus of claim 10 further comprising

2   a power source to provide power to the cache; and

3   a recovery module to recover the organization of the cache on power up following

4   a loss of power to the cache from the power source by

5   in a first phase of recovery, for each line in the cache

6   determining if the line is allocated;

7   if the line is allocated, inserting the line in a set of the cache using a

8   mapping based on the tag associated with the line; and

9   if the line is not allocated, inserting the line into a pool of unallocated

10   lines; and

11   in a second phase of recovery, for each set in the cache

12   determining the number of pinned lines in the set using the metadata

13   associated with each line in the set; and

14   moving one or more lines from the pool of unallocated lines to each set

15   that has at least one pinned line so that the number of non-pinned lines in

16   each set is approximately the same.

1   12.   (Original) A system comprising

2   a processor;

3   a disk communicatively coupled to the processor;

4   an N-way set associative cache implemented in non-volatile battery-backed up

5   Dynamic Random Access Memory communicatively coupled to the processor;

6   a pinned data portion of the non-volatile flash memory to store a pool of lines for

7   pinned data; and

8   a pinned data insertion module to

9   insert pinned data into a line from the pool of lines for pinned data;

10   mark the line as being allocated by modifying metadata associated with

11   the line;

12   determine a set into which the line using a mapping based on the tag

13   associated with the line;

14   remove the line from the pool for pinned data; and

15   add the line to the set.

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2   13. (Currently Amended) A ~~machine readable~~ tangible machine readable medium

3   having stored thereon data which when accessed by a machine causes the machine

4   to perform ~~the~~ a method, ~~of claim 1~~ the method comprising:

5   reserving a first number of unallocated lines in the cache for pinned data, the first

6   number being less than the number of lines in the cache; and

7   if data needs to be inserted into the cache as pinned data,

8   selecting a line from the lines reserved for pinned data;

9   storing the data in the line; and

10   inserting the line into a search group of the CATB cache.

1   14. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 13 wherein each line of the cache is stored in non-volatile memory

3   ~~having stored thereon further data which when accessed by a machine causes the~~

4   ~~machine to perform the method of claim 2~~.

1   15. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 14 ~~having stored thereon further data which when accessed by a machine~~

3   ~~causes the machine to perform the method of claim 3~~ wherein the method further

4   comprises:

5   recovering the organization of the cache on power up following a loss of

6   power to the cache by

7   in a first phase of recovery, for each line in the cache

8   determining if the line is allocated;

9   if the line is allocated, inserting the line in a search group of the cache; and

10   if the line is not allocated, inserting the line into a pool of free lines;

11   and

12   in a second phase of recovery, for each search group

13   determining the number of pinned lines in the search group; and

14   adding at least one line from the pool of free lines to each search group

15   that has at least one pinned line.

1   16. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 15 wherein the cache is a disk cache in a processor based system ~~having~~

3   ~~stored thereon further data which when accessed by a machine causes the machine~~

4   ~~to perform the method of claim 4~~.

1   17. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 13 wherein the method further comprises

3   indicating that the line is allocated;

4   indicating that the line is pinned; and

5   using a tag of the line to map the line to a search group of the cache ~~having stored~~

6   ~~thereon further data which when accessed by a machine causes the machine to~~

7   ~~perform the method of claim 5~~.

1   18. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 17 <u>wherein the method further comprises the CATB cache is</u>

3   <u>implemented as a set-associative cache;</u>

4   <u>each search group of the cache is a set of the cache; and</u>

5   <u>inserting the line into a search group of the cache further comprises:</u>

6   <u>using the address of the data as the tag of the line;</u>

7   <u>performing a modulus operation between the tag and the number of</u>

8   <u>sets (N) in the cache (the tag MOD N) to map the tag to a set of the</u>

9   <u>cache;</u>

10   <u>performing a search based on the tag of the line; and</u>

11   <u>inserting the line into a dynamic data structure that represents the</u>

12   <u>set.</u> ~~having stored thereon further data which when accessed by a~~

13   ~~machine causes the machine to perform the method of claim 6.~~

1   19. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 18 <u>wherein indicating that the line is pinned further comprises</u>

3   <u>modifying metadata associated with the line to indicate that the line is</u>

4   <u>pinned.</u>~~having stored thereon further data which when accessed by a machine~~

5   ~~causes the machine to perform the method of claim 7.~~

1   20. (Currently Amended) A ~~machine readable~~ tangible machine readable medium

2   having stored thereon data which when accessed by a machine causes the machine

3   to perform, ~~the method~~ for a whole number N, in an N-way set associative non-

4   volatile disk cache, a method comprising:

5   reserving a predetermined number of lines for pinned data and organizing

6   them into a pool of lines for pinned data;

7   distributing the remaining lines in the cache into N dynamic data

8   structures of approximately the same size to represent the N sets of the

9   cache;

10   if data is to be inserted into the cache as pinned data,

11   inserting the data into a line from the pool for pinned data;

12   marking the line as allocated by modifying metadata associated

13   with the line;

14   determining the set to which the line belongs using a mapping

15   based on the tag associated with the line;

16   removing the line from the pool for pinned data; and

17   adding the line to the set. ~~of claim 8.~~

1   21. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 20 ~~having stored thereon further data which when accessed by a machine~~

3   ~~causes the machine to perform~~ wherein the method ~~of claim 9~~ further comprises:

4   recovering the organization of the cache on power up following a loss of

5   power to the cache by

6   in a first phase of recovery, for each line in the cache

7   determining if the line is allocated;

8   if the line is allocated, inserting the line in a set of the cache using

9   a mapping based on the tag associated with the line; and

10   if the line is not allocated, inserting the line into a pool of

11   unallocated lines; and

12   in a second phase of recovery, for each set in the cache

13   determining the number of pinned lines in the set using the

14   metadata associated with each line in the set; and

15   moving one or more lines from the pool of unallocated lines to

16   each set that has at least one pinned line so that the number of non-

17   pinned lines in each set is approximately the same.

1   22. (Original) In a Constant Access Time Bounded (CATB) cache, a method

2   comprising:

3   initializing a search group of the CATB cache with a capability to dynamically

4   insert and delete elements; and

5   inserting elements dynamically into the search group of the CATB.

1   23. (Original) The method of claim 22 further comprising:

2   receiving a first identifier for an element;

3   using the first identifier to compute a second identifier for a search group in the

4   CATB cache; and

5   traversing the search group to locate an element matching the first identifier.

1   24. (Original) The method of claim 23 wherein the search group is implemented as a

2   linked list.

1   25. (Currently Amended) A ~~machine readable~~ tangible machine readable medium

2   having stored thereon data which when accessed by a machine causes the machine

3   to perform ~~the~~ a method ~~of claim 22~~the method comprising:

4   initializing a search group of the CATB cache with a capability to

5   dynamically insert and delete elements; and

6   inserting elements dynamically into the search group of the CATB.

1   26. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 25 ~~having stored thereon further data which when accessed by a machine~~

3   ~~causes the machine to perform~~ wherein the method ~~of claim 23~~further comprises:

4   receiving a first identifier for an element;

5   using the first identifier to compute a second identifier for a search group

6   in the CATB cache; and

7   traversing the search group to locate an element matching the first

8   identifier.

1   27. (Currently Amended) The ~~machine readable~~ tangible machine readable medium

2   of claim 25 ~~having stored thereon further data which when accessed by a machine~~

3   ~~causes the machine to perform the method of claim 24~~ wherein the search group is

4   implemented as a linked list.